Chapter 2

Virginia Energy Resources and Consumption

This Plan sets a goal to increase the in-state production of energy by 20 percent by 2017 over what is projected in the base case. Increasing in-state production of energy will keep funds otherwise spent on energy imports in Virginia's economy and decrease the potential risk Virginia consumers face from disruptions in energy supplies.

2.0 Virginia Energy Resources and Consumption

Electricity, natural gas, propane, and other fuels used in our homes and buildings and gasoline and diesel fuel used for transportation are supplied to Virginia consumers from in-state production of coal, natural gas, and renewable fuels, from in-state generation of electricity, and from imports of petroleum, electricity (and uranium used to generate electricity), natural gas, coal, propane, and other fuels. The difference between the amount of energy produced in a state and the amount consumed is called its net energy balance. Virginia's net energy balance is negative as most energy used in Virginia comes from imports.

Energy consumption typically increases with population growth and rising household incomes, which allow for more disposable income to purchase larger homes and energy-consuming devices. Therefore, as Virginia's population and income have grown, energy consumption has grown. This growth in consumption has happened at the same time that in-state production of energy has decreased, so Virginia's negative net energy balance has been growing.

Virginia's 2005 population of 7.5 million was the twelfth highest of the fifty states. Average annual growth in population was nearly 1.4 percent between 1995 and 2005, slightly higher than the national average of 1.2 percent. The population is projected to increase at an annual average rate of 1.1 percent over the next twenty years, compared with 0.8 percent for the United States as a whole.[2]

Virginia's median household income in 2005 was $54,240, more than 17 percent higher than the national median income. Similarly, the average per capita income of $29,148 was more than 16 percent higher than the national average. Approximately 7 percent of Virginia's families live below the poverty level, compared with a national average of just over 10 percent.

While Virginia's in-state production of energy has declined since 1990, Virginia must increase the amount of energy it produces to help meet the growing energy demand of its citizens and businesses. This Plan sets a goal to increase the in-state production of energy by 20 percent by 2017 over what is projected in the base case. Increasing in-state production of energy will keep funds otherwise spent on energy imports in Virginia's economy and decrease the potential risk Virginia consumers face from disruptions in energy supplies.

2.1 Energy Production

Energy production in Virginia consists primarily of coal, electricity, and natural gas. Petroleum and renewable and alternative fuel sources produce only a small percentage of energy used in the state.

2.1.1 Coal Production

Driven by industry expansion in western states, U.S. coal production increased steadily over the last twenty years, while Appalachia's share of total coal production decreased. Virginia's coal production declined from a peak of 46.5 million tons in 1990 to 31.7 million tons in 2006. Costs associated with mining the relatively thin seams found in Virginia's underground mining operations have led to this decline. Much of western coal production comes from less costly surface mines.

Historically, Virginia ranks among the top ten coal-producing states. In 2006, it ranked tenth. Wyoming (444.9 million short tons), West Virginia (151 million), and Kentucky (119.6 million) are the top three coal-producing states. Virginia mines coal in the Central Appalachian Basin in the seven southwestern counties of Lee, Scott, Wise, Buchanan, Dickenson, Russell, and Tazewell.

Virginia's coal industry consists predominately of small operations that develop remnant or finite above-drainage reserves using the room and pillar mining method. These small operations comprise approximately 70 percent of Virginia's mining activities. Although a typical small operator employs fewer than thirty-six people, together these operators have a significant

[2] Source: U.S. Census Bureau, Population Division, Interim State Population Projections, 2005.

employment and economic impact on the rural communities of southwest Virginia. Virginia is home to a small number of larger mines. One large underground mine producing coal from a longwall mining operation in Buchanan County employs more than 300 people and produces more than 2 million tons per year.

Since 1980, modern equipment, improved miner training, and better mine designs have allowed miner productivity to more than double while the number of licensed mines has declined by half. In the early 1980s, Virginia had more than 10,000 coal-production employees. Today that figure fluctuates between 4,500 and 5,000.

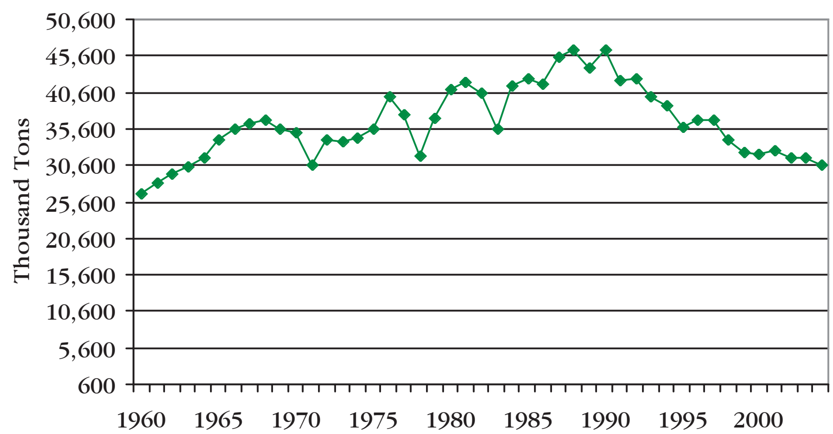
The majority of Virginia's future coal production will come from small underground operations augmented by surface contour and high-wall mining operations. This future capacity depends on the ability of small coal operators to remain productive and competitive.

Mining disasters in 2006 prompted new federal legislation known as the Mine Improvement and New Emergency Response Act of 2006, or MINER Act. The Act requires improvements in miner training, emergency oxygen supplies, communication, and mine rescue services. The new law will increase safety in underground coal mines but may cause some small mines to close.

Coal production contributes substantially to the state's economy. A 1995 study conducted by the Virginia Center for Coal and Energy Research concluded that each mining job supported three non-mining jobs. Severance taxes paid by the coal industry support local and state government and contribute to economic diversification of the coalfield region through the Virginia Coalfield Economic Development Authority.

Coal will continue to be an attractive fuel source for the electric utility industry as clean-coal technologies advance.

Figure 2-1 Virginia Coal Production, 1960-2004

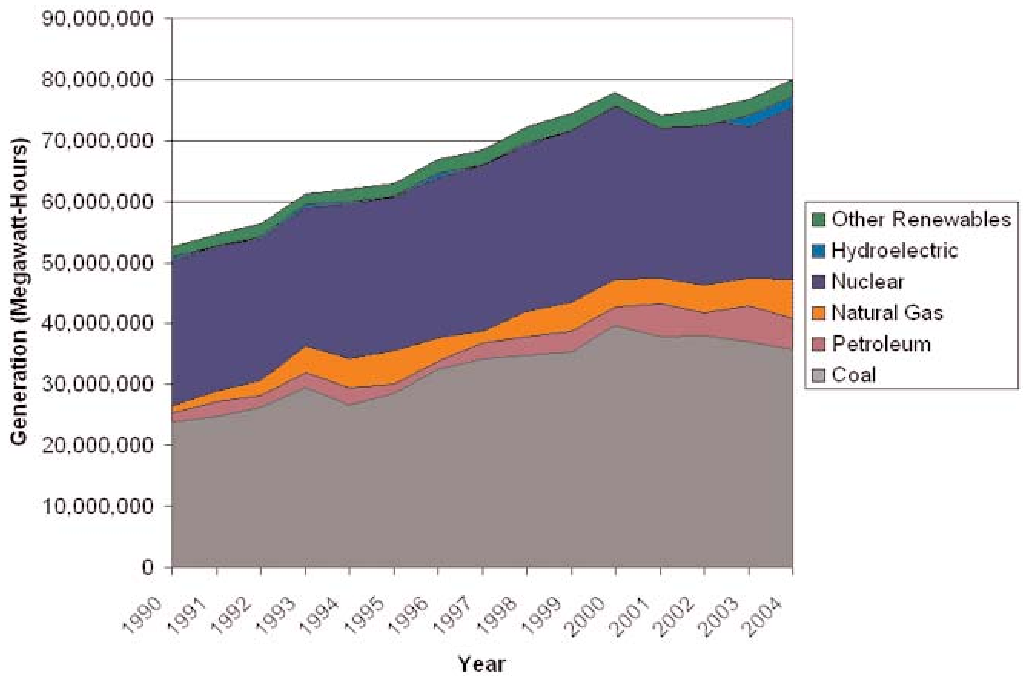


Future coal production rates in Virginia should be more stable. Coal will continue to be an attractive fuel source for the electric utility industry as clean-coal technologies advance. Several next-generation alternative-fuel technologies are targeting carbon-rich materials, including coal and waste coal, as the feedstock of choice. Many of these technologies use new processes that limit greenhouse gas releases, making the use of coal an easier choice. Carbon-to-liquids represents a new industry for Virginia. Jobs associated with this industry would be centered near locations of feedstock and production. The coalfields offer attractive production sites and a ready workforce.

2.1.2 Electricity Production

Electric generating plants in Virginia produced 78,900 gigawatt-hours of electricity in 2004. Electricity production in Virginia increased by an average of 2.4 percent, or 1,685 gigawatt-hours per year, from 1994 through 2004. In 2004, 45 percent of the electricity generated in Virginia came from coal and 36 percent from nuclear power plants. The remaining production came from hydro, natural gas, petroleum, and renewable sources. Approximately half of the coal burned in the state's coal-fired power plants is from Virginia mines. Most of the remaining coal is imported from West Virginia and Kentucky. Figure 2-2 provides a breakdown of electric generation in Virginia by fuel type for 1990 to 2004.[3]

Figure 2-2 Virginia's Electric Energy Net Generation by Fuel Type, 1990-2004



Emissions from electrical production in Virginia are less than what would be expected from just looking at the state's generation capacity. In 2004, Virginia had a net summer generating capability of 22.5 gigawatt-hours, the sixteenth highest in the nation. In terms of emission rates, it ranked eighteenth in the nation in sulfur dioxide, thirty-third in nitrogen oxides, and twenty-ninth in carbon dioxide (see Table 2-1).[4] These emissions are better than the national average because of the high proportion of nuclear and hydroelectric power Virginia produces.

Table 2-1 Virginia Electric Generation Emissions, 2004

Chemical	Amount (lbs/MWh)	U.S. Rank*
Sulfur Dioxide	6.1	18
Nitrogen Dioxide	1.9	33
Carbon Dioxide	1,309	29

** A rank of 1 means the highest production of emissions.*

[3]Source: Virginia Energy Patterns and Trends.
[4]Source: Energy Information Administration.

Virginia's electric sector is well positioned to respond to future growth. Recent utility legislation provides both a focus on conservation and incentives for new power plants. Virginia's electric generators also have the potential to sell excess off-peak generation in the northeast PJM markets where capacity margins are slim and prices are higher. There also are opportunities associated with developing renewable energy options and retiring old generation capacity in favor of newer, more efficient, and cleaner plants.

The opportunity to balance the need for increased supply by placing more emphasis on efficiency gains, conservation, and demand-side management is addressed in Chapter 3.

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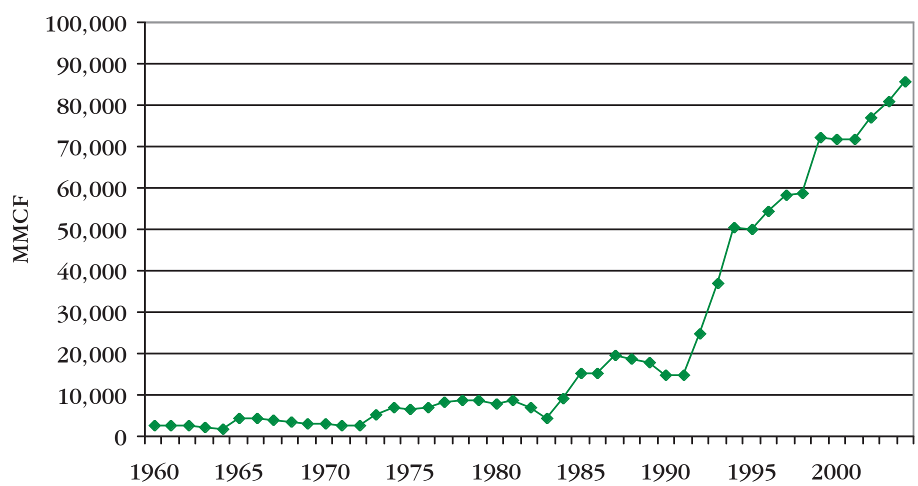
2.1.3 Natural Gas Production

Virginia's natural gas production has experienced rapid growth since the early 1990s, exceeding 5 percent annually. In 2005, Virginia produced 88.6 billion cubic feet (MMCF) of gas. This is equivalent to 32 percent of the state's annual demand across all end users, more than the entire residential demand.[5] Natural gas production in 2004 represented 7 percent of total primary energy production in the state.[6] Most of the increase in natural gas production has been from expanded extraction in Buchanan and Dickenson Counties.[7] Natural gas production and development activities contribute substantially to the local economy in southwest Virginia's gas-producing counties. Figure 2-3 presents annual natural gas production data in Virginia for 1960-2004.

Figure 2-3 Natural Gas Production in Virginia, 1960-2004



Coalbed methane is the most common source of natural gas produced in Virginia. Its extraction produces a marketable product from what used to be a troublesome by-product of coal mining.

Natural gas is fed from the well where it is produced into a system of gathering lines, which connect to facilities that compress the gas into a pipeline-quality product. After processing, the gas is fed into the interstate pipeline network where it is consumed in Virginia and other eastern states.

While natural gas production in the coalfield region will continue to rise incrementally, long-term sustained increases are limited by depleting reserves. In December 2005, Virginia's natural gas reserves were estimated to be 2,018 billion cubic feet.[8] Given current removal rates, this reserve would last about twenty-five years.[9] New discoveries and changing technologies may extend Virginia's reserve base and allow production to be maintained at high levels for a longer period of time.

[5] www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_072.pdf.
[6] Virginia Energy Patterns and Trends, Statewide Energy Overview Table.
[7] Virginia Energy Patterns and Trends.
[8] Energy Information Administration, Advance Summary: U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 2005 Annual Report.
[9] This annual natural gas removal rate shown is based on a three-year average rate of production for the years 2002-2004.

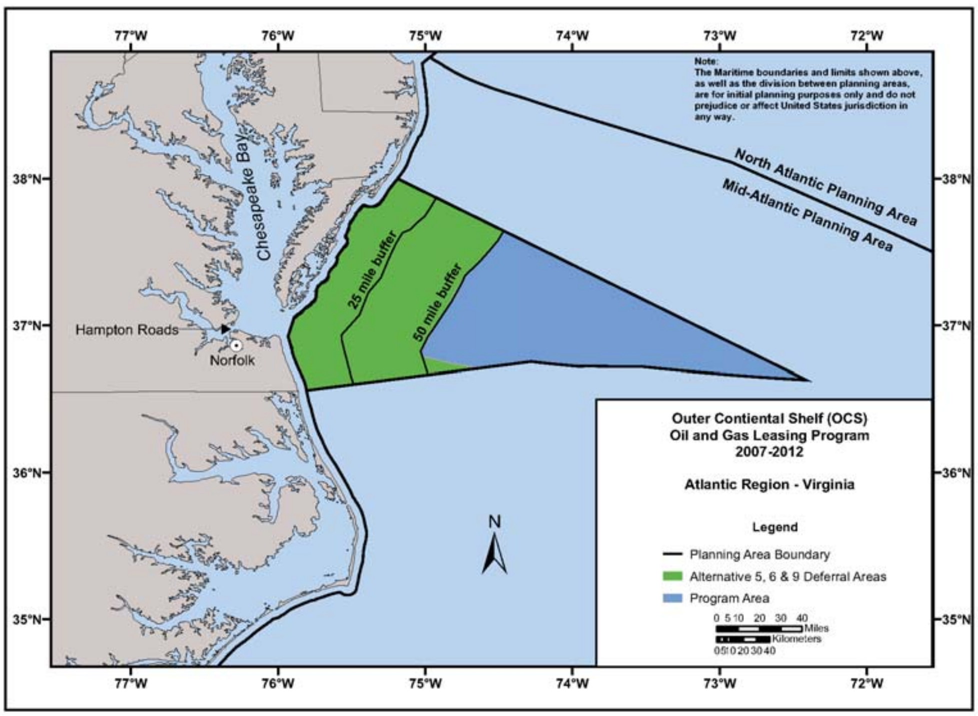
Virginia's natural gas utilities, marketers, and some large businesses purchase natural gas during summer months when it is cheaper and store it for use in winter when it is more expensive. Natural formations suitable for such storage are being used in Smyth County near Saltville and in Scott and Washington Counties near Bristol.

While natural gas deposits may be available from Atlantic offshore areas, there is a congressional moratorium on producing oil or natural gas from new areas of the outer continental shelf and a presidential withdrawal of offshore lands from consideration for oil and gas leasing. With the recent rise in natural gas prices, there has been new interest in producing these offshore resources. The Department of Interior's Minerals Management Service (MMS) has revised its 2007-2012 Outer Continental Shelf Oil and Gas Leasing Program to include a possible lease sale off the Virginia coast in 2011.

Figure 2-4 shows this lease sale area.[10] The area excludes a buffer to 50 miles from Virginia's coastline and at the mouth of Chesapeake Bay.

While natural gas production in the coalfield region will continue to rise incrementally, long-term sustained increases are limited by depleting reserves.

Figure 2-4: Mid-Atlantic OCS Lease Area Proposed by MMS off Virginia



The MMS estimates that the conventionally recoverable fossil fuel resource in the proposed lease area is 56 million barrels of oil and 327 billion cubic feet of natural gas. It further estimates that forty years would be required to lease, explore, develop, and produce these resources.

Virginia has established as its policy on development of these offshore resources that only offshore exploration of natural gas no closer than 50 miles to the shore should be approved at this time.[11] The Commonwealth needs more information about the potential size of the resource before it can make final decisions regarding the approval of production.

Several milestones would have to be met before any drilling could begin, including:

- Congress would have to lift its moratorium on coastal exploration and production.
- The president would have to lift the executive order prohibiting exploratory and leasing activities.

[10]Source: U.S. Department of the Interior, MMS, Proposed Final Program of the Outer Continent Oil and Gas Leasing Program, 2007-2012, April 2007, map 9, p. 68.
[11]See the Code of Virginia, Section 67-300.

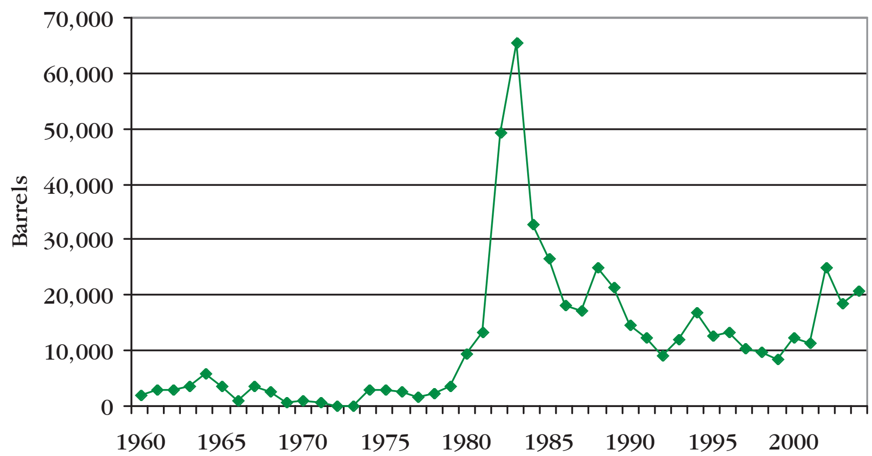
- Industry would have to demonstrate sufficient interest in federal waters off Virginia's coast.
- Proposed exploratory plans would have to go through both a federal environmental assessment and a state review for consistency with Virginia's coastal management regulations.

The MMS established state administrative boundaries in outer continental shelf waters using an equidistance methodology for the purpose of managing offshore resources. The equidistance methodology expands the areas attributable to states with convex coastlines and decreases the areas attributable to states, such as Virginia, with concave-shaped coastlines. Use of equidistant boundaries reduces the Commonwealth's ability to influence decisions about offshore resource development. This will affect not only natural gas extraction but also sand, other minerals, and renewable energy resources. The MMS should revise the administrative boundaries to more equitably reflect coastal states' interests.

2.1.4 Petroleum Production

Virginia is a very small petroleum producer. In-state production represents only one one-hundredth of 1 percent of total state energy production and occurs only in Lee and Wise Counties. Figure 2-5 shows Virginia's petroleum production for the years 1960-2004.

Figure 2-5 Petroleum Production in Virginia, 1960-2004



2.1.5 Renewable Energy Production

Renewable energy production in Virginia comes from hydroelectric power, landfill gas, geothermal energy, solar and photovoltaic energy, wind energy, biomass, and waste energy. Renewable energy production in Virginia (largely hydroelectric) remained relatively stable from 1990 to 2004 (see Figure 2-6), representing less than one tenth of 1 percent of total energy produced in the state. This amount would be greater if energy from non-metered sources, such as solar hot water heating, passive solar, hot springs, and other small-scale on-site renewable energy systems, could be counted.

Virginia has significant untapped renewable energy resources, including wind, tidal, solar, biomass, municipal solid waste, and others. Advanced technology and manufacturing, along with strong university research and development capability, put Virginia in a good position to capitalize on these forms of energy.

[2]http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_072.pdf

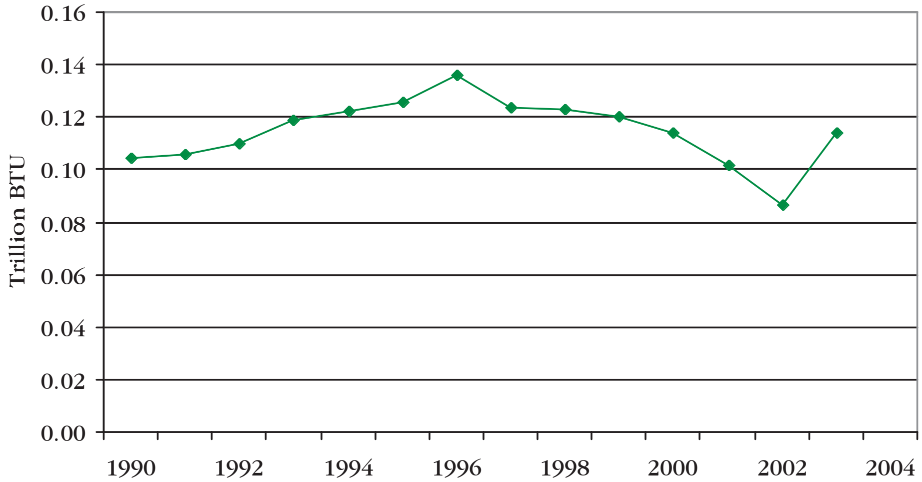
[3]Virginia Energy Patterns and Trends, "Statewide Energy Overview Table".

[4]Virginia Energy Patterns and Trends.

[5]Energy Information Administration, Advance Summary - U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 2005 Annual Report.

[6]The annual natural gas removal rate shown here is based upon a three-year average rate of production for the years 2002 to 2004.

Figure 2-6 Renewable Energy Production in Virginia, 1990-2004*



**Source: Energy Information Administration*

The demand for renewable resources is expected to escalate due to the growing public concern regarding global warming and reducing greenhouse gas emissions coupled with the rising cost of environmental compliance for conventional energy sources. Technology advancements are making renewable sources increasingly competitive. The renewable portfolio standard incentives included in the 2007 electric utility legislation provide a platform for Virginia's utilities to further diversify their generation mix with renewable sources.

Virginia currently has about 580 megawatts (MW) of operational non-hydro renewable energy capacity. There is technical potential to develop nearly 44,000 megawatts.[12] The largest technical potential is from wind energy and solar photovoltaic (PV) electricity, followed by biomass combustion and landfill gas (see Table 2-2). However, reaching this potential is probably beyond the ten-year horizon addressed in this Plan. Advancements in technology and reductions in cost are needed for Virginia to reach this goal.

Virginia has significant untapped renewable energy resources, including wind, tidal, solar, biomass, municipal solid waste, and others. Advanced technology and manufacturing, along with strong university research and development capability, put Virginia in a good position to capitalize on these forms of energy.

Table 2-2 Virginia's Technical Renewable Energy Potential Generating Capacity

Renewable Energy Resource	2002 Installed Capacity in Virginia (MW)	Virginia Potential Installed New Capacity (MW)	Capacity Factor
Land-based wind	0.01	1,950	30-45%
Offshore wind	0	28,100	35-40%
Solar PV	0.22	11,000 - 13,000	14%-20%
Biomass combustion	415	760	83%
MSW/Landfill gas	168	30	90%
TOTAL	**583.23**	**41,840 - 43,840**	

[12] There may be less usable production from these sources because of low capacity factors for some renewable sources, particularly solar- and wind-powered projects.

Chapter 2

Virginia Energy Resources and Consumption

continued

2.2 Energy Imports and Exports

Virginia must import energy to fill the gap between in-state production and use. Except for coal, energy consumption for each type of fuel far exceeds in-state production. Figure 2-7 and Table 2-3 show the net imports and exports of each fuel source in 2004. Figure 2-8 shows how the net amounts have changed over time. A negative figure indicates net exports. Supply-side additions, demand-side management, and conservation could alter the net import ratio. Closing this gap between imports and in-state production could be a significant economic opportunity for Virginia.

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Closing this gap between imports and in-state production could be a significant economic opportunity for Virginia.

Figure 2-7 Virginia's Net Energy Imports/(Exports), 2004

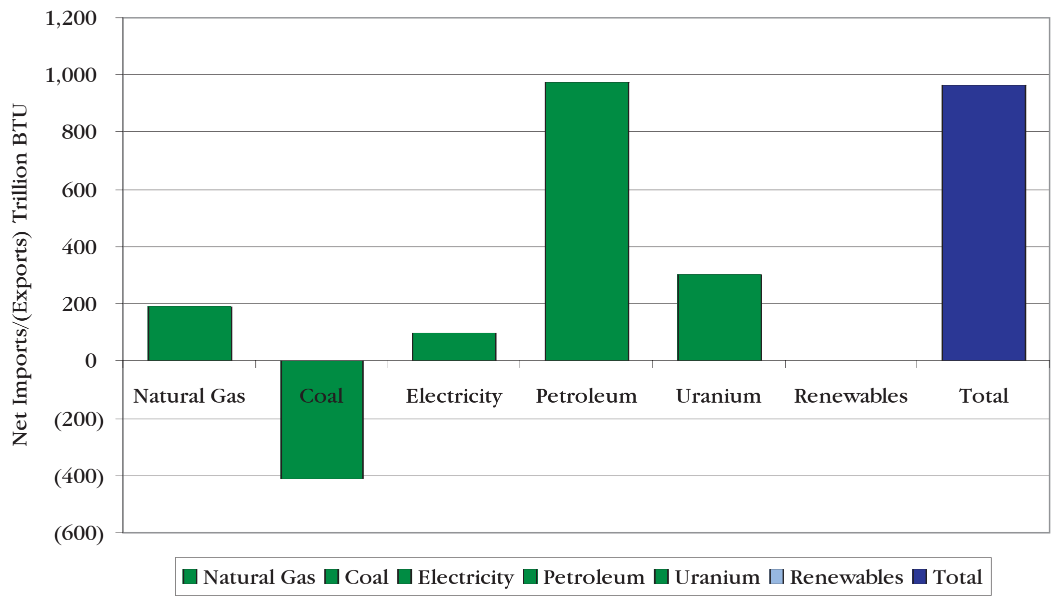
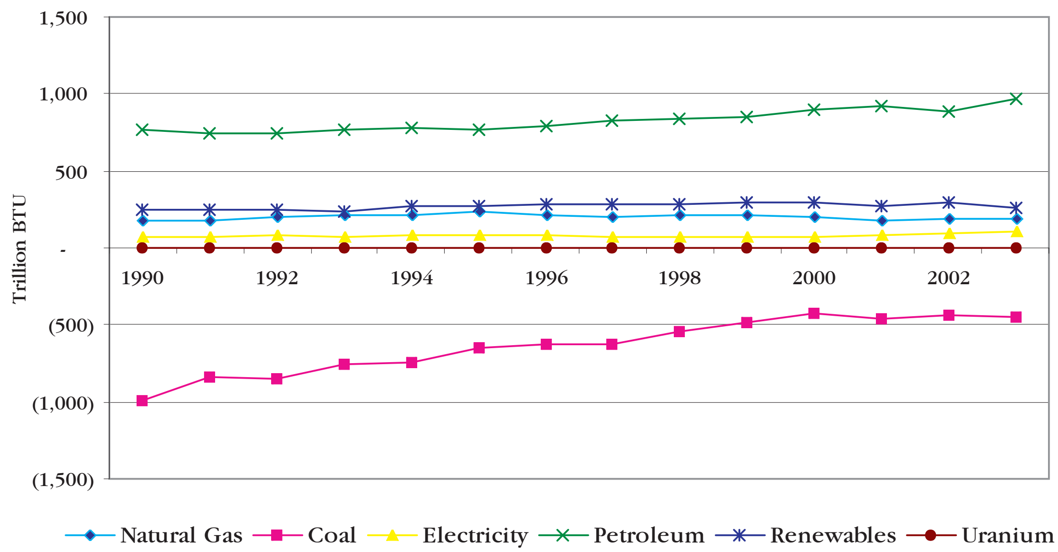


Table 2-3 Virginia's Net Energy Imports/(Exports), 2004

Fuel	Production	Consumption	Net Imp/(Exp)	% of Consumption
Coal	881.0	469.6	-411.4	187.60%
Electricity	253.8	353.8	100.0	28.30%
Natural Gas	88.2	277.7	189.4	68.20%
Petroleum	0.1	975.6	975.5	100.00%
Uranium	0.0	300.8	300.8	100.00%
Renewables	0.1	0.1	0.0	0.00%
Total	1,223.3	2,377.6	1,154.3	48.60%

Figure 2-8 Virginia's Net Energy Imports/(Exports) by Fuel, 1990-2003



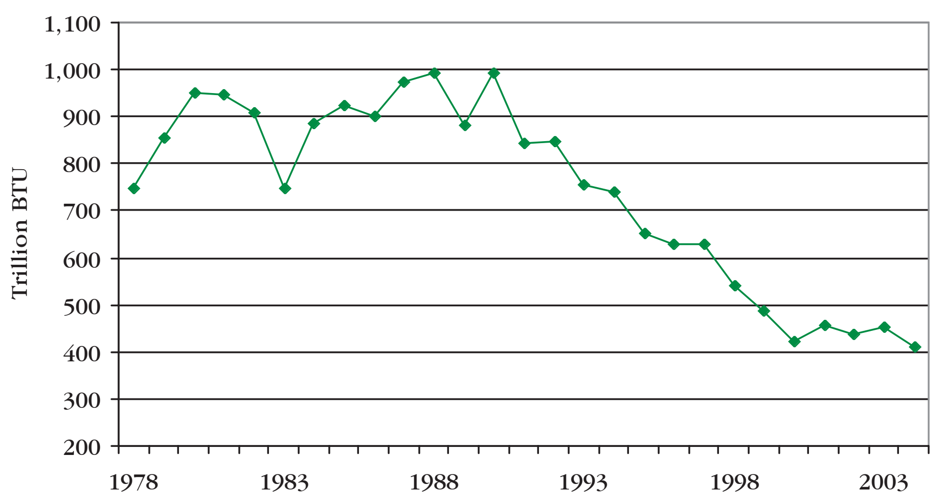
The following subsections look at each fuel type in more detail.

2.2.1 Coal Exports

Virginia continues to be a net exporter of coal, shipping 411.4 trillion BTUs, or 47 percent of 2004 coal production, out of the state. As indicated in Figure 2-9, there has been a decline in coal exports since the late 1980s.

Coal production is expected to decline by an average rate of 3 percent per year from 2006 to 2016, after which time it is expected to reach a more stable level. Conversely, coal consumption is expected to increase by 1.9 percent per year. The increase will come from the proposed Virginia City Hybrid Energy Center and increased use of existing coal-fired power plants. No growth has been projected for

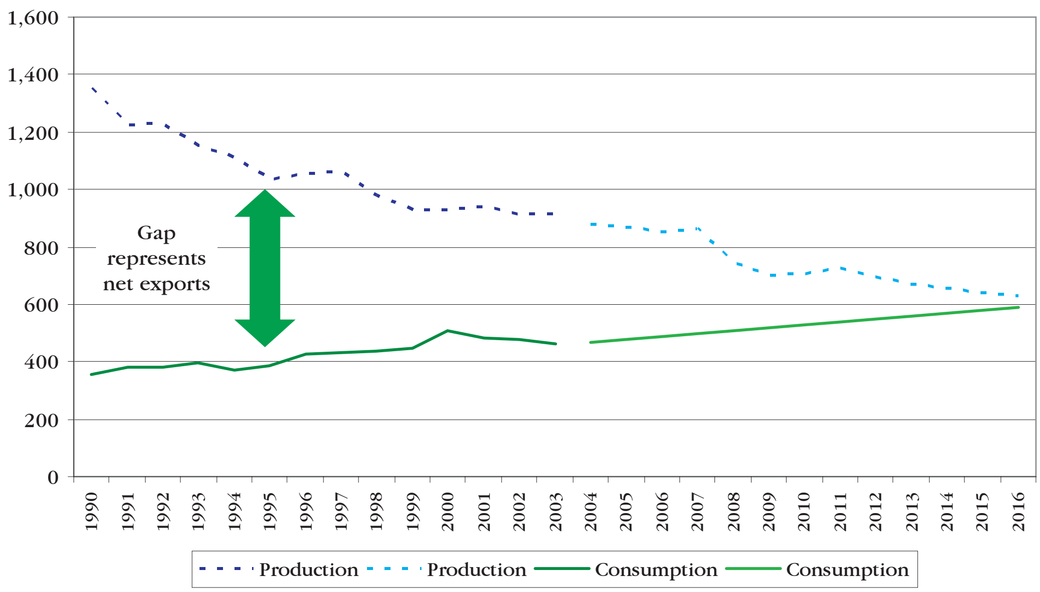
Figure 2-9 Virginia's Net Coal Exports



coal-to-liquid plants. Any plants coming on-line in Virginia would increase the state's coal consumption.

If the production and consumption trends continue, Virginia could become a net coal importer as early as 2018 (see Figure 2-10). However, external forces affecting Virginia's coal markets and production may change this projection.

Figure 2-10 Virginia's Coal Production-Consumption Gap, 1990-2017 *(Trillion BTUs)*

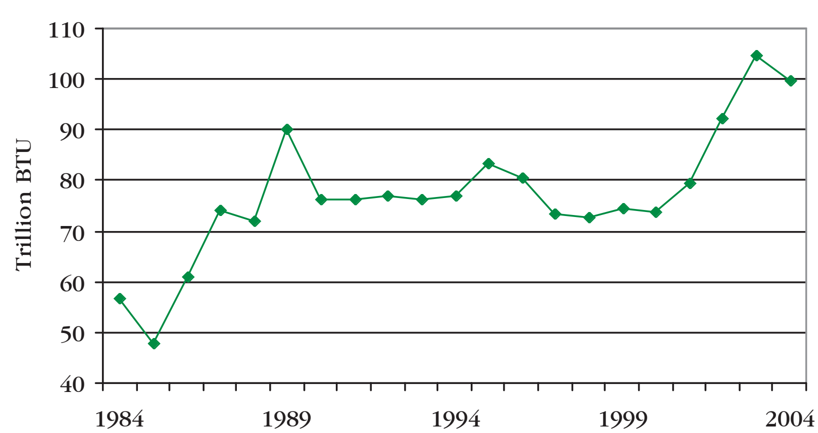


2.2.2 Electricity Imports

Virginia imported nearly one-third of its electricity in 2004. Imports of electricity have been growing over time, ranging from 22 percent of total use in 1990 up to just below 30 percent in 2005. Figure 2-11 shows the growth in net electricity imports over time.

Some of Virginia's electricity imports come from the Mount Storm electric generating station which is 100 percent committed to serving Virginia consumers. Other imports come from facilities, such as those operated by Appalachian Power and Allegheny Power, dedicated to serving an individual utility's consumers in its Virginia and non-Virginia service territories. A third group of imports comes from economic purchases through bilateral sales or through PJM markets.

Figure 2-11 Virginia's Net Electricity Imports, 1984-2004



Virginia can close its electricity import gap with a combination of energy efficiency, demand-side management, and electric generation additions. A variety of production, conservation, and import scenarios (see Table 2-4) were developed to illustrate this potential. The total demand growth over the next ten years is projected to be 7,224 megawatts without any new energy efficiency or demand-side management. Virginia would need to add approximately 5,100 megawatts of generation capacity by 2016 in order to maintain a 30 percent import ratio.[13] If Virginia can reduce its electricity use by 14 percent (see Chapter 3 for a discussion of conservation potential) while holding its import ratio stable, then the state would only need 1,220 megawatts of new power generation capacity by 2016. A 10 percent reduction would result in Virginia needing an additional 2,358 megawatts of new generation capacity. Lowering the electricity import ratio would require production of more power from in-state facilities. Any increase in electricity imports would require increases in high-voltage transmission capacity.

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Table 2-4 Electricity Import Scenarios for Virginia

Scenario	Year	Peak Electrical Demand for Virginia (MW)	Conservation & Energy Efficiency Savings	Conservation & Energy Efficiency (MW)	Net Summer Generation Capacity (MW)	Net Generation Change (MW)	Electricity Imports (% of Total Capacity)
Base Case	2005	32,026	0%	0	22,599		29.4%
1	2016	39,250	0%	0	22,599	0	42.4%
2	2016	39,250	0%	0	27,697	5,098	29.4%
3	2016	33,755	14%	5,495	22,599	0	33.0%
4	2016	33,755	14%	5,495	23,819	1,220	29.4%
5	2016	33,755	14%	5,495	33,755	11,156	0%

	Scenario
	Base historical year - 2005
1	No conservation and efficiency impacts, No new production
2	No conservation and efficiency impacts, new generation added at a rate needed to maintain base-year import proportion
3	14% conservation and efficiency impacts, no new production
4	14% conservation and efficiency impacts, new generation added at a rate needed to maintain base-year import proportion
5	14% conservation and efficiency impacts, new generation added at a rate needed to reduce imports to zero

These trends and forecasts are based on net imports and exports for the entire state and do not break out new infrastructure needs in areas where growth rates are highest or in areas otherwise affected by constraint or congestion.

[13]Based on the incremental energy consumption by 2016 and the relationship between Virginia's summer capacity and annual energy consumption in 2004.

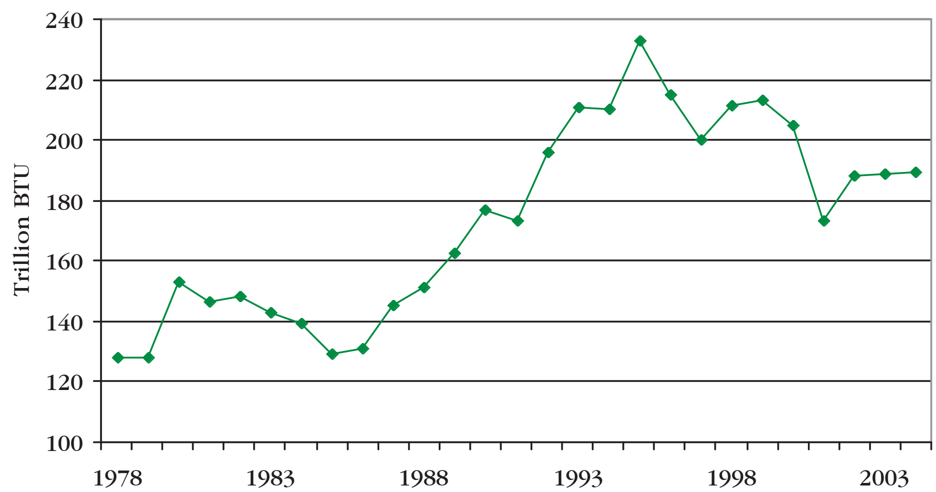
2.2.3 Natural Gas Imports

Approximately two-thirds of the natural gas consumed in Virginia comes from imports. Net imports of natural gas rose sharply from 1985 through 1995 and then fell after 1995 as in-state production increased (see Figure 2-12).

Future natural gas load, and therefore net imports, will be affected by changes in use of natural gas for electric generation and increased use in response to economic growth. Net natural gas imports could be reduced through increased efficiency and conservation. Reducing the peak electricity loads that rely on natural gas generation could also help reduce the need for natural gas imports. These options are discussed in Chapter 3.

A gallon of gas not used domestically eliminates nearly 2 gallons of oil being imported from abroad.

Figure 2-12 Virginia's Net Natural Gas Imports, 1978-2003



2.2.4 Petroleum Imports

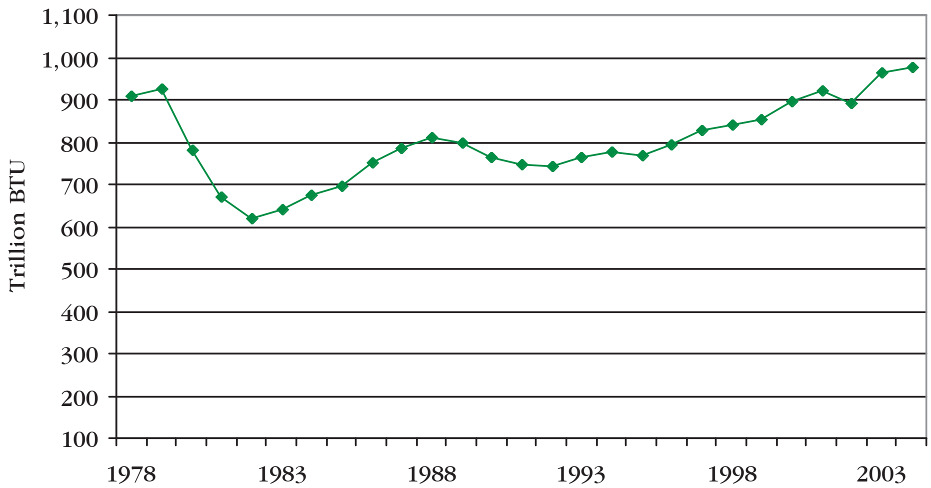
Nearly all of the petroleum Virginia consumes is imported (see Figure 2-13). Petroleum consumption grew by approximately 2.3 percent per year from 1994 to 2004. This caused net imports to increase at the same rate.

Reducing consumption of conventional petroleum products and offsetting petroleum with Virginia-derived alternative fuels could reduce imports. For example, a gallon of gas not used domestically eliminates nearly 2 gallons of oil being imported from abroad.[14] According to information from the Governors' Ethanol Coalition, for every 100 million gallons of local ethanol produced (the annual capacity of a typical plant), more than 168 million gallons (4 million barrels) of imported oil would be offset and more than $200 million would be reduced from the trade deficit.

Reducing consumption, and thereby imports, can occur with different mechanisms and initiatives. The transportation sector represents the largest area of opportunity as it uses 75 percent of Virginia's petroleum.[15] These options are discussed in Chapter 3.

[14]See www.auto.howstuffworks.com/question417.htm. This website states that a barrel of oil (which contains 42 gallons, or 159 liters) will yield 19 or 20 gallons (75 liters) of gasoline, depending on the refinery.
[15]Virginia Energy Patterns and Trends.

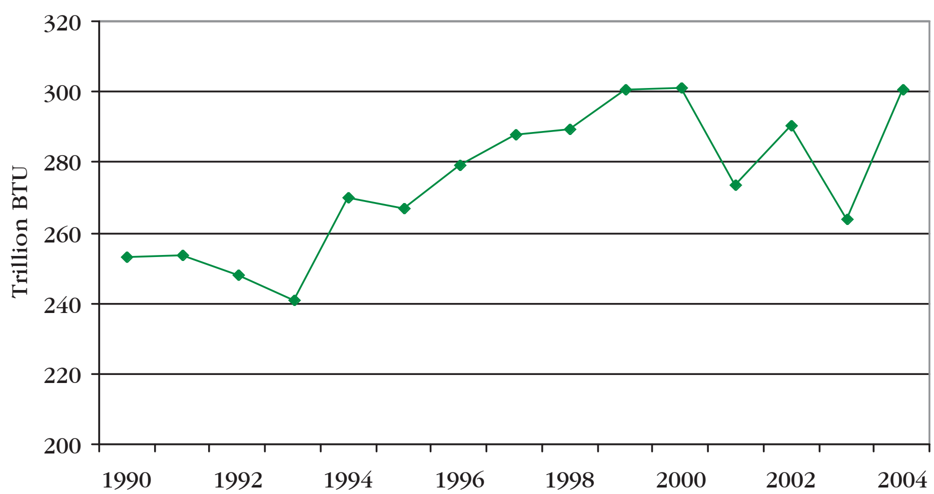
Figure 2-13 Virginia's Net Petroleum Imports,1978-2003



2.2.5 Uranium Imports

All of the uranium used to fuel Virginia's North Anna and Surry nuclear power plants is imported (see Figure 2-14). Virginia consumes around 1.6 million pounds of uranium per year.[16] An expansion of the North Anna power plant would result in increased uranium imports. The potential to mine Virginia uranium is therefore strategically important and warrants careful analysis.

Figure 2-14 Virginia's Net Uranium Imports, 1990-2004



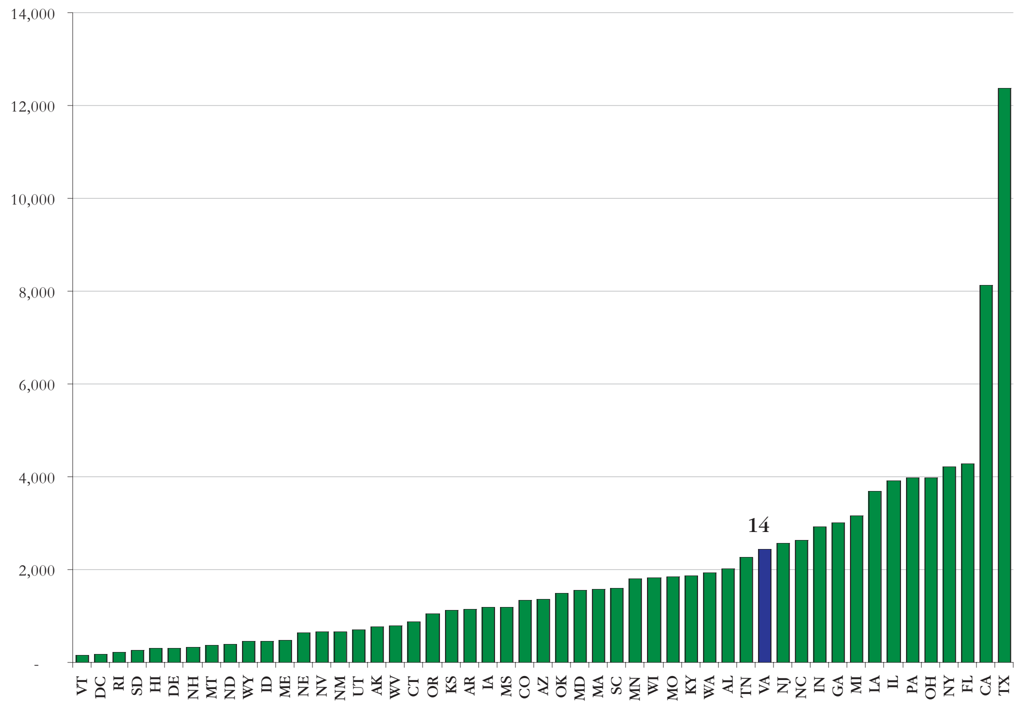
[16]According to Mr. Hink Barker, manager of nuclear fuel procurement for the North Anna and Surry facilities, these two plants use approximately 1.6 million pounds of unenriched uranium each year. This number is based on a range of 1.3 to 1.9 million pounds per year, depending on how many units are refueled in any given year. The input uranium is natural uranium at 0.7% U235. It needs to be enriched up to the 4.2 to 4.7% level. The enrichment process creates many pounds of waste during the conversion to enriched nuclear fuel. The final amount of enriched (higher U235 percent) uranium that actually goes into the reactor core is about 30 metric tons (approximately 66,000 pounds) per year for the type of reactors in Virginia.

2.3 Energy Consumption

Virginia ranks fourteenth in the nation in total energy consumption (see Figure 2-15). This is slightly lower than its twelfth-place population ranking. Virginia ranks tenth in commercial energy consumption, twelfth in both residential and transportation, and seventeenth in industrial. The state ranks twenty-fourth in total consumption per capita, because of the relatively higher urban population percentage and lower industrial intensity of the state's economy.

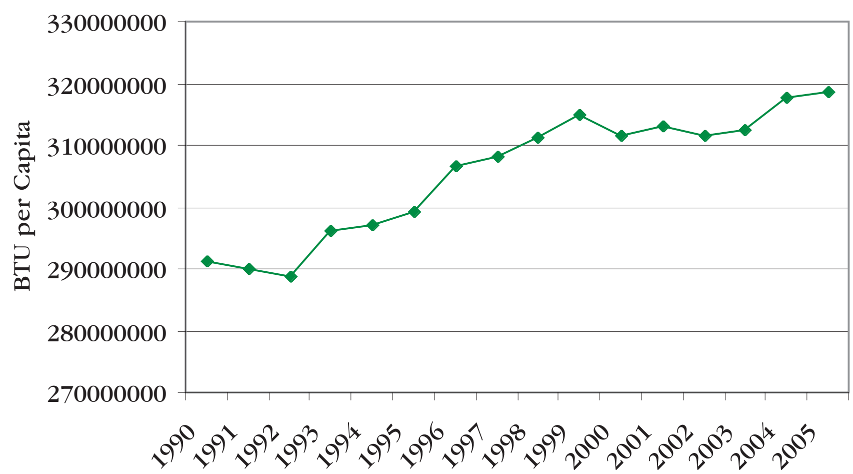
Virginia ranks fourteenth in the nation in total energy consumption. This is slightly lower than its twelfth-place population ranking.

Figure 2-15 State Rankings of Total Energy Consumption



Another useful way to look at energy use is to consider the amount used by each person in Virginia. Energy use per capita in the state grew from 291 million BTUs in 1990 to 319 by 2005 (see Figure 2-16). This is equivalent to an average growth rate of approximately six tenths of 1 percent per year.

Figure 2-16 Virginia's Per Capita Energy Use, 1990-2005



[10]Based on Energy Information Administration data with the exception of uranium, which is estimated by applying the 2004 heat rates for the two nuclear facilities to electricity generated.

2.3.1 Energy Consumption by Sector

Figure 2-17 shows Virginia's growth in energy consumption by sector for 1960 through 2003.[17] Figure 2-18 shows a snapshot of this data for 2003.

Energy use for transportation has grown at the fastest rate. The commercial sector has experienced the smallest growth. Energy use in other sectors has fluctuated but exhibited overall upward trends. Figure 2-19 presents Virginia's energy consumption by sector for 1960 and 2003.

Figure 2-20 shows the breakout of energy use by source for each sector.[18] Because of its growth rate, the transportation sector is now the state's single largest energy-using sector, accounting for approximately 43 percent of total energy use (measured at the end-use point, i.e., the meter or pump). Of the remaining 57 percent, 17 percent is used in the residential sector, 15 percent in the commercial sector, and 25 percent in the industrial sector.

Figure 2-17 Virginia's Total Energy Consumption by Sector, 1960-2003

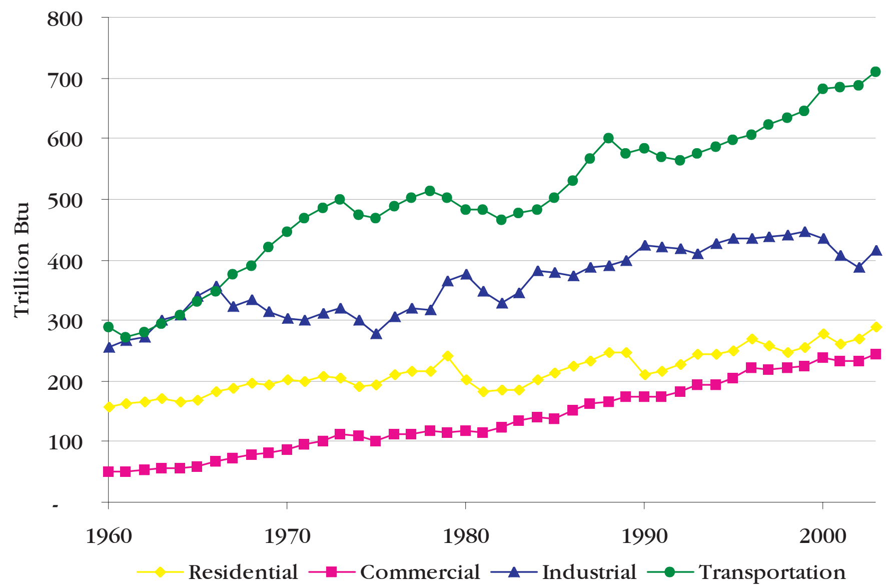
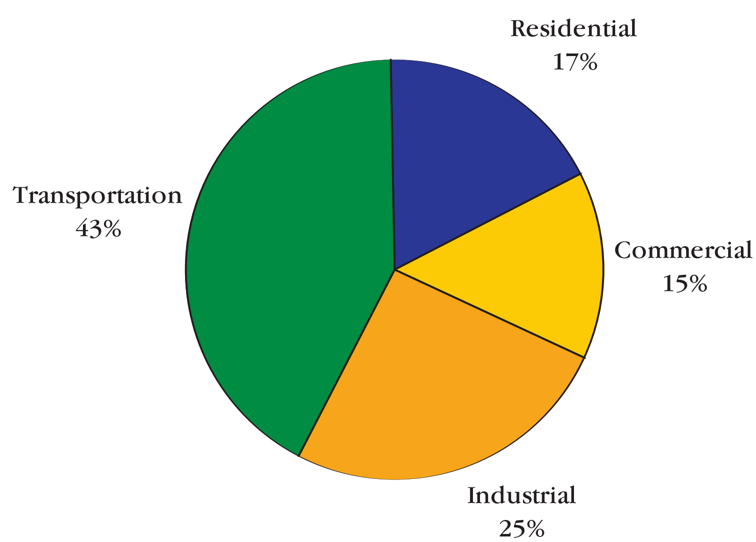


Figure 2-18 Virginia's Total Energy Consumption by Sector, 2003



[17]Data show the energy used at the point of consumption (site data) and do not include the energy used to produce or deliver the electricity, petroleum, natural gas, and other energy to the end users (source data). If electric generation and transmission losses are included in the calculations, transportation energy use decreases to approximately 33% of total energy use.

[18]Fuel sources have different properties which affect how much they are used in any sector. Fuel suppliers often compete against each other based on fuel properties such as ease of use, cost, carbon footprint, safety, and other factors. Ultimate efficiencies and environmental impacts of energy use by each source depend on factors, many of which are not measured with a great degree of rigor, related to production, processing, and transportation of the energy to end users.

Figure 2-19 Virginia's Total Energy Consumption Profile by Sector, 1960 and 2003

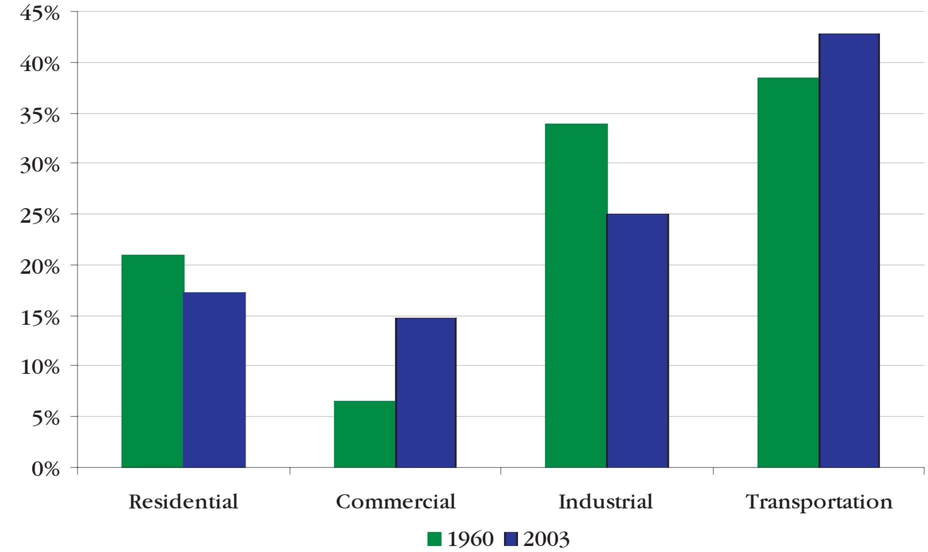
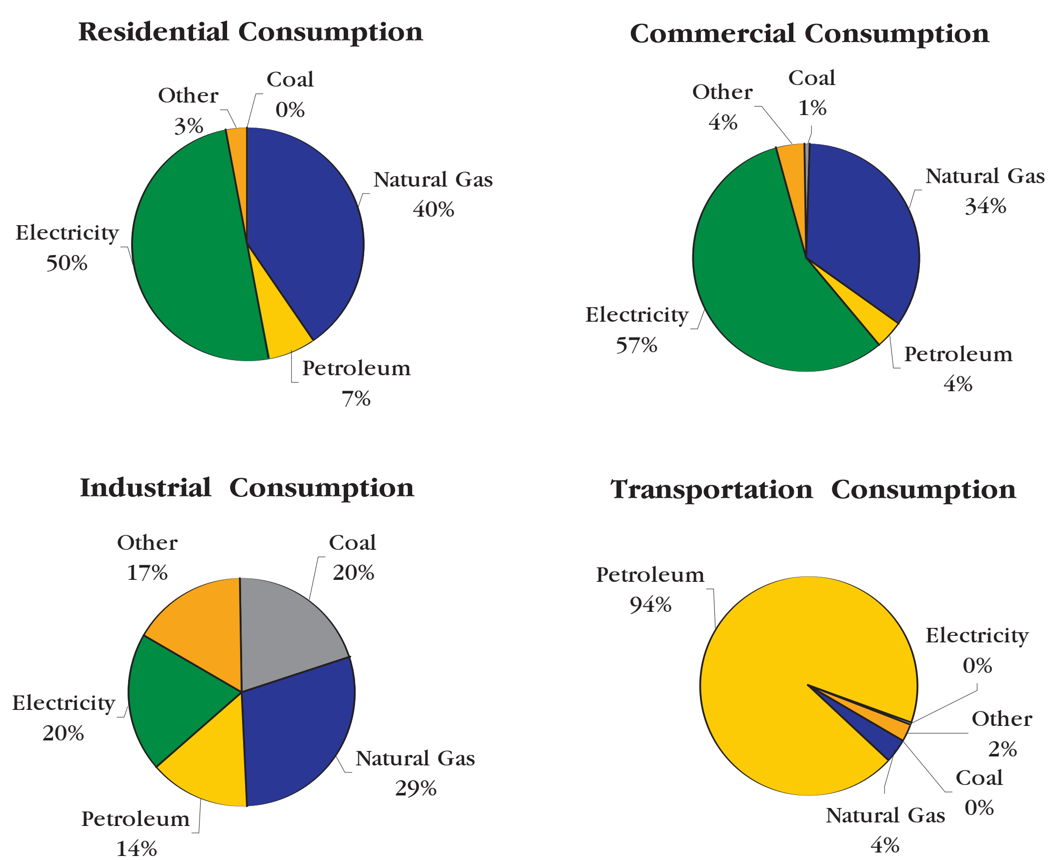


Figure 2-20 Virginia's Energy Consumption by Sector, 2003



Residential Consumption

The condition of a state's housing stock has a significant effect on energy use. Virginia housing stock is younger, larger, and higher in value than the national average. This causes Virginia's housing stock to be more efficient on a per-square-foot basis than the national average, but greater in energy use because of the larger size and higher presence of energy-using equipment in higher value housing.

Table 2-5 summarizes and compares the primary heating fuels for homes in Virginia and the nation. Natural gas is not available in many of the rural and mountainous regions of Virginia; therefore, relative to the country as a whole, Virginia homes use a much higher proportion of electricity as their primary heating fuel.

Table 2-5 Virginia Heating Fuel Market Share

House Heating Fuel Market Share	Virginia	U.S.
Utility gas	35.2%	50.5%
Bottled, tank, or LP gas	5.3%	6.0%
Electricity	45.6%	32.5%
Fuel oil, kerosene, etc.	10.6%	8.0%
Coal or coke	0.1%	0.1%
Wood	2.4%	1.7%
Solar energy	0.0%	0.0%
Other fuel	0.4%	0.4%
No fuel used	0.3%	0.8%

Commercial Consumption

Commercial energy use is heavily electric. Most is used to light, heat, and cool commercial spaces, refrigerate goods, and power computers. Electric use has grown as more information technology and other electric equipment have been added.

Industrial Consumption

Industrial energy use is more evenly distributed among fuel types. Industrial energy use is primarily driven by process needs. Energy is used to drive motors, to handle materials, as a feedstock to industrial processes, and as a thermal input to manufacturing.

Transportation Consumption

Transportation is almost totally fueled by petroleum. Most transportation energy use is for moving automobiles, trucks, and aircraft. Transportation energy use will remain heavily dependent on petroleum until non-petroleum alternate sources, such as ethanol, biodiesel, and coal-to-liquids, are developed.

Chapter 2

Virginia Energy Resources and Consumption

continued

2.4 Energy Production and Consumption Forecasts

Historical trends and industry data were used to project energy production and consumption trends in Virginia. The difference between energy production and consumption is Virginia's energy balance and reflects its net energy imports and exports. Table 2-6 shows Virginia's total energy production and consumption base case forecasts.

Table 2-6 Energy Production and Consumption Forecasts for Virginia *(Billion BTUs)*

Year (a)	Amount Produced (b)	Growth (c)	Percent Growth (d)	Amount Consumed (e)	Growth (f)	Percent Growth (g)	Net Imported/ (Exported) (h)	Growth (i)	Percent Growth (j)
1990	1,536,048.0			1,811,416.1			275,368.1		
1991	1,417,819.9	(118,228.1)	-7.7%	1,826,877.6	15,461.5	0.9%	409,057.7	133,689.6	48.5%
1992	1,436,762.3	18,942.3	1.3%	1,852,395.2	25,517.6	1.4%	415,633.0	6,575.2	1.6%
1993	1,393,331.8	(43,430.5)	-3.0%	1,927,796.1	75,400.9	4.1%	534,464.3	118,831.3	28.6%
1994	1,367,985.1	(25,346.7)	-1.8%	1,959,115.0	31,319.0	1.6%	591,129.9	56,665.7	10.6%
1995	1,296,980.7	(71,004.4)	-5.2%	1,996,636.3	37,521.2	1.9%	699,655.6	108,525.7	18.4%
1996	1,330,417.8	33,437.1	2.6%	2,070,035.6	73,399.3	3.7%	739,617.8	39,962.2	5.7%
1997	1,346,573.8	16,156.1	1.2%	2,105,239.1	35,203.5	1.7%	758,665.3	19,047.4	2.6%
1998	1,276,797.0	(69,776.8)	-5.2%	2,147,401.7	42,162.6	2.0%	870,604.7	111,939.4	14.8%
1999	1,247,525.2	(29,271.9)	-2.3%	2,203,962.9	56,561.2	2.6%	956,437.8	85,833.0	9.9%
2000	1,258,281.4	10,756.2	0.9%	2,312,418.9	108,455.9	4.9%	1,054,137.5	97,699.7	10.2%
2001	1,263,185.9	4,904.5	0.4%	2,252,304.1	(60,114.8)	-2.6%	989,118.2	(65,019.3)	-6.2%
2002	1,245,569.4	(17,616.5)	-1.4%	2,269,029.3	16,725.3	0.7%	1,023,460.0	34,341.8	3.5%
2003	1,238,495.8	(7,073.6)	-0.6%	2,307,218.2	38,188.8	1.7%	1,068,722.4	45,262.4	4.4%
2004	1,223,247.3	(15,248.5)	-1.2%	2,377,552.0	70,333.8	3.0%	1,154,304.7	85,582.3	8.0%
2005	1,214,006.5	(9,240.8)	-0.8%	2,410,705.4	33,153.4	1.4%	1,196,698.9	42,394.2	3.7%
2006	1,210,208.5	(3,798.0)	-0.3%	2,443,858.8	33,153.4	1.4%	1,233,650.3	36,951.4	3.1%
2007	1,234,311.0	24,102.5	2.0%	2,477,012.2	33,153.4	1.4%	1,242,701.1	9,050.9	0.7%
2008	1,130,256.4	(104,054.7)	-8.4%	2,510,165.6	33,153.4	1.3%	1,379,909.2	137,208.1	11.0%
2009	1,091,638.6	(38,617.8)	-3.4%	2,543,319.0	33,153.4	1.3%	1,451,680.4	71,771.2	5.2%
2010	1,112,831.0	21,192.4	1.9%	2,576,472.4	33,153.4	1.3%	1,463,641.4	11,961.0	0.8%
2011	1,141,107.5	28,276.5	2.5%	2,609,625.8	33,153.4	1.3%	1,468,518.3	4,876.9	0.3%
2012	1,122,109.9	(18,997.6)	-1.7%	2,642,779.2	33,153.4	1.3%	1,520,669.3	52,151.0	3.6%
2013	1,106,721.1	(15,388.8)	-1.4%	2,675,932.6	33,153.4	1.3%	1,569,211.5	48,542.2	3.2%
2014	1,104,684.4	(2,036.6)	-0.2%	2,709,086.0	33,153.4	1.2%	1,604,401.6	35,190.0	2.2%
2015	1,102,647.8	(2,036.6)	-0.2%	2,742,239.4	33,153.4	1.2%	1,639,591.6	35,190.0	2.2%
2016	1,100,611.2	(2,036.6)	-0.2%	2,775,392.8	33,153.4	1.2%	1,674,781.7	35,190.0	2.1%
COMPOUND GROWTH RATES									
1993-1998	-1.7%			2.2%			10.3%		
1998-2003	-0.6%			1.4%			4.2%		
2003-2008	-1.8%			1.7%			5.2%		
2008-2013	-0.4%			1.3%			2.6%		
2003-2016	-0.9%			1.4%			3.5%		

Figure 2-21 presents Virginia's net energy imports and exports for the years 2004 and 2016. Even with a decline in coal production, Virginia is expected to continue to be a coal exporter through the ten-year window of this Plan. The state is expected to continue being a net importer of natural gas, petroleum, nuclear, and electricity.

Figure 2-21 Virginia's Net Energy Imports/(Exports), 2004 and 2016

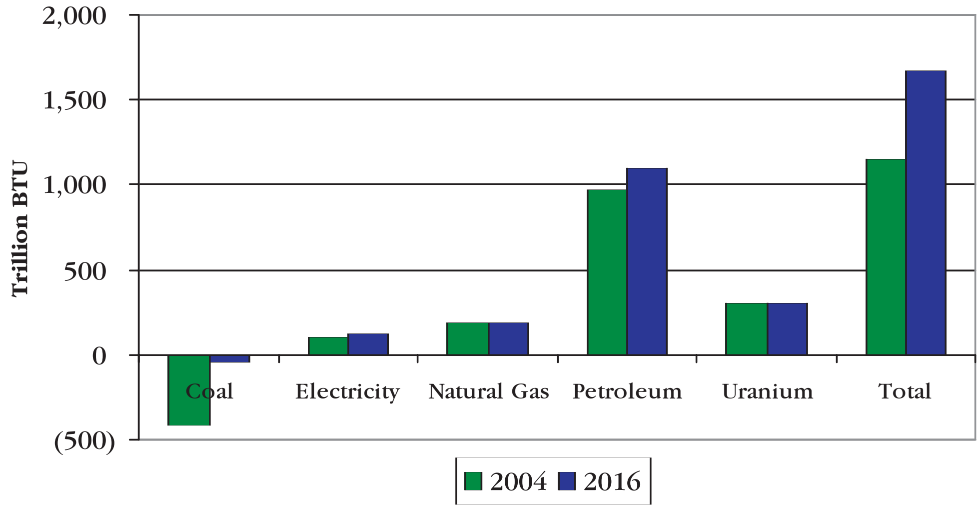
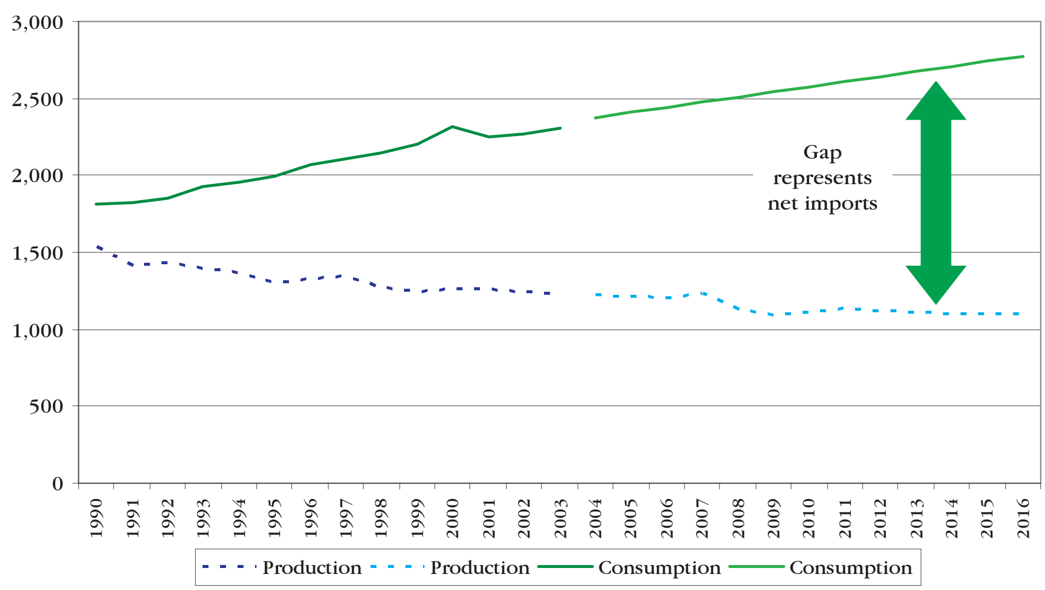


Figure 2-22 presents the historical and projected (base case) energy production and consumption ratio for the years 1990 to 2016. With no new supply- or demand-side measures, the gap between energy consumed and produced in Virginia is expected to increase from 1,154 trillion BTUs in 2004 to 1,639 trillion BTUs in 2016. The 2004 gap had a market value of $9.3 billion. The gap in 2016 would be $15.9 billion in today's prices, an increase of 4.6 percent per year from 2004 through 2016.

Figure 2-22 Virginia's Energy Supply and Demand Gap *(Trillion BTUs)*



Virginia can choose to actively pursue early commercial use of new technologies. Near-term generation options include clean coal, solar, wind, nuclear, and waste and biomass. Longer-term options, available ten or more years from now, include tidal/in-stream water, high-temperature geothermal energy, hydrogen, and methane hydrates.

2.5 Impact of Utility Regulation and Restructuring

Over the last decade, Virginia opened the door to electric utility deregulation. A fully developed marketplace would have promoted competition and resulted in efficient and low-cost electric service. However, the competition once envisioned has not materialized. Therefore, the Virginia General Assembly directed the State Corporation Commission (SCC) to continue regulatory oversight.[19]

Instead of returning to the traditional system of utility regulation, the legislation established a hybrid mechanism for regulating the rates of investor-owned electric utilities. The new process prescribes utility rates of return, while recognizing the impact that utility regulation has on financing needed infrastructure improvements. In addition, each utility may seek rate-adjustment clauses to recover:

- Costs for services provided by PJM under Federal Regulatory Energy Commission approved demand-response programs.
- Costs of authorized deferred environmental and reliability improvements.
- Costs of authorized demand-management, conservation, energy-efficiency, and load-management programs.
- Costs of participation in the new renewable portfolio standard.
- Costs of projects that the SCC finds to be necessary to comply with state or federal environmental laws or regulations applicable to generation facilities used to serve the utility's native load obligations.

If the SCC reviews rates and determines that a utility earned less than its authorized rate of return, rates will be increased to a level that allows rate of return. If the SCC determines that a utility earned more than its established rate of return, the SCC is required to direct that 60 percent of overearnings be credited to customers' bills.

The Commonwealth has made the renewable portfolio standard available to electric utilities that show a reasonable expectation of achieving 12 percent of base-year electric energy sales from renewable energy sources by 2022. Under the voluntary program, a utility that meets renewable energy goals can earn an increased rate of return. The utility also can earn an enhanced rate of return on the construction costs of generation facilities used to provide the renewable energy. Double production credits are provided for energy from solar or wind sources.

The legislation provides that customers with an electrical demand of more than 5 megawatts, but less than 1 percent of the utility's load, may shop for power. Nonresidential customers may aggregate their demand to meet the 5-megawatt threshold. Municipalities are allowed to aggregate the electric load of their governmental operations to negotiate rates and terms of service.

The legislation provides incentives for construction of new base-load generation to protect consumers from high-cost, volatile wholesale electricity markets.

The legislation is intended to provide an outlet for competition while protecting those consumers who cannot competitively shop for electricity. Predicted outcomes include improved utility infrastructure, rate increases less than those in neighboring states, increased use of renewables, and increased efficiency and conservation.

2.6 Role of New Technologies

As new technologies advance and become competitive, they will naturally come to market. Virginia can choose to actively pursue early commercial use of new technologies. Near-term generation options include clean coal, solar, wind, nuclear, and waste and biomass. Longer-term options, available ten or more years from now, include tidal/in-stream water, high-temperature geothermal energy, hydrogen, and methane hydrates. New conservation technologies are addressed in Chapter 3.

Virginia's businesses and institutions are

[19] http://leg1.state.va.us/cgi-bin/legp504.exe?071+ful+HB3068ER+pdf.

conducting research on many of these potential longer-term energy solutions. While the commercial use of many of these products may be beyond the ten-year term of this Plan, returns on research and development of these products can begin sooner. Chapter 6 contains further information about these energy research and development activities.

2.6.1 Near-Term Technologies

Clean Coal

Advanced circulating fluidized bed technology is a proven clean-coal technology that can produce power with reduced emissions. This flexible technology can be used with run-of-mine coal, waste coal, and renewable energy sources such as wood waste. The Virginia City Hybrid Energy Center is being engineered for 20 percent co-firing of renewable or waste fuel.

Integrated Gasification Combined Cycle (IGCC) plants uses gasified coal to fuel a conventional combined cycle power plant. This is another near-term technology that can produce power with reduced emissions. There are currently two coal-based IGCC plants in the United States, in Florida and Indiana.[20] They represent the cleanest coal-based technology operating today. American Electric Power has proposed building two IGCC plants, one of which will serve Appalachian Power customers.

Coal (or other carbon)-to-liquids is an emerging technology that offers promise. Rapid advancements may bring projects to Virginia in less than five years.

Virginia has the opportunity to sequester carbon in unminable coal seams. A recent report from the Virginia Center for Coal and Energy Research (VCCER) provides detailed information on this opportunity.[21] Preliminary conclusions indicate that coal in the Central Appalachian Basin has significant sequestration potential, particularly in Buchanan, Dickenson, and Wise Counties. An estimated 7.33 trillion cubic feet of carbon dioxide storage capacity is available in the unminable Lee and Pocahontas formation coals in southwest Virginia. There is an estimated 4.94 trillion cubic feet of technically feasible storage capacity of areas currently developed for coalbed methane production. An additional 0.9 trillion cubic feet of coalbed methane may be produced due to the enhanced recovery resulting from carbon dioxide injection.

Nuclear

Nuclear power plant design has evolved since the first-generation prototypes were built in the 1950s and 1960s. Generation III+ reactors are under development and likely to be deployed by 2010. These include the Economic Simplified Boiling Water Reactor, which Dominion has identified as the reactor of choice in its North Anna plant siting license applications. Other companies, including Areva NP in Lynchburg, offer competing designs. Pebble bed reactors are being developed in South Africa and Asia.

While operational costs of nuclear power plants are the lowest of any type of generation except for hydroelectric, wind, and solar, nuclear power's high capital cost is a deterrent to its construction. Additionally, the United States needs to find a permanent solution to nuclear fuel disposal. However, fossil-fueled plants continue to incur costs to control emissions. With future carbon taxes or emissions trading requirements, nuclear power generation is expected to grow.

Uranium Production

There is a renewed interest in uranium exploration and mining due to rising uranium prices. Wyoming (the largest U.S. producer of uranium with the largest reserve base, according to the National Mining Association), Utah, and Colorado are states with the greatest potential for additional extraction.

Federal law and regulations control many uranium mining activities, including the Uranium Mill Tailings Radiation Control Act of 1978, the Safe Drinking Water Act, the Underground Injection Control Program, and the National Emission Standards for Hazardous Air Pollutants. The federal government controls the licensing of uranium-processing mills and

[20] ConocoPhillips and Cinergy jointly operate the Wabash River Generating Station in West Terre Haute, IN. This facility is a repowering of an existing coal plant with 262 megawatts of capacity. It became operational in 1995 and was a DOE demonstration project, receiving 50% of the total project funding from DOE during a four-year demonstration phase. The Polk Power Station is an IGCC facility run by Tampa Electric Company in southern Florida. The plant has 250 megawatts of capacity and was also a part of the DOE's demonstration program, receiving $120 million in federal funds. The project was placed in commercial operation in 1996 and continues to operate commercially for Tampa Electric Company today.

[21] In May 2004, DOE commissioned VCCER and Marshall Miller & Associates, Inc. to conduct an assessment of the carbon sequestration potential of the Pennsylvanian-age coalbeds in the Central Appalachian Basin.

disposal of the associated mill tailings. Beyond the general environmental protection programs, there is no federal program that regulates mine operation, reclamation, and closure. Some states (e.g., Wyoming, Colorado, and Texas) have developed uranium mining standards

Uranium deposits were discovered about thirty-five years ago at Coles Hill in Pittsylvania County, but uranium has never been mined from the site. According to a 1983 report by Marline Uranium Corporation, a deposit estimated at 30 million tons could yield a potential annual extraction rate of approximately 2 million pounds per year. Applying the March 2007 price of $85 per ton[22] equals a market value of $170 million per year.

The prospect of uranium mining in Virginia was extensively studied by the Virginia Coal and Energy Commission in the early 1980s. At the conclusion of these studies, the commission issued Senate Document 15 (1985) which recommended that a Virginia uranium industry be allowed to develop within a specific and detailed legislative framework designed to protect the public health and environment. Following this report, Virginia prohibited uranium mining but established a regulatory program for uranium exploration. The Commonwealth would need to develop operational and reclamation requirements for uranium mining and milling before the moratorium on extraction could be lifted.

For every one million pounds of uranium oxide produced per year, an estimated 200 direct jobs would be created. Marline estimated in 1983 that during thirteen years of operations at the Swanson mine and mill, approximately 2.3 million pounds of uranium oxide would be produced each year and about 453 direct jobs created. Marline estimated that the project would create an additional 312 indirect jobs statewide. It also indicated that with more exploration, additional uranium might be discovered in Pittsylvania and adjacent counties. Production at the mine and mill could be expanded to accommodate the increased reserves.

Initial environmental and land-use studies that evaluated the impact of the project found that surface and groundwater impact would be minimal. No significant deep, regional aquifers were identified in the area of the deposit. Any development would have to be carefully designed, developed, and monitored to ensure that the operation would not affect surface and groundwater.

The proposed Marline uranium mine would have used 1,265 acres, with the mine pit affecting 135 acres, waste rock and mill tailings disposal areas covering 930 acres, the mill covering 25 acres, and support area covering 175 acres.

Significant opportunities existing in other areas of the nuclear industry are addressed later in this Plan. They include research, development, construction, and operation of new generation reactors (see Chapter 4), fuel processing, servicing the nuclear navy, and providing high-tech workforce training.

Municipal Solid Waste

Virginia is the nation's second largest importer of municipal solid waste.[23] Decomposing solid waste creates methane, which when captured at landfill sites can be used to generate electricity. Biomass generation facilities may also be located at landfill sites.

Virginia has more than seventy landfills with active projects at nineteen of these sites. The U.S. Environmental Protection Agency's Landfill Methane Outreach Program identifies approximately fifteen more sites as attractive candidates for landfill gas projects, with many of the remaining forty considered project "potential."

Virginia has several plants that convert waste and biomass into energy (see Chapter 4). Covanta's I-95 Energy/ Resource Recovery Facility processes 3,000 tons a day of municipal solid waste and has a generating capacity of 79 megawatts of electricity, and its Alexandria/Arlington Resource Recovery Facility processes 975 tons of solid waste a day and has a generating capacity of 23

[22]Ux Consulting Company, March 5, 2007, U3O8 spot price.
[23]Department of Environmental Quality, Office of Policy and Legislation, "Report on the Management of Municipal Solid Waste in the Commonwealth of Virginia: A Historical Review," November 1998, available at www.deq.state.va.us.

megawatts. Another example includes the Southeast Public Service Authority, which operates a municipal solid waste plant in Portsmouth. The plant is designed to process 1,500 tons per day. It produces process steam and electricity for the Norfolk Naval Shipyard and sells excess electricity to Dominion.

In addition, Virginia is following technologies that convert solid waste into alternative liquid fuels. Several technologies are in advanced stages, with one that uses a bio-catalytic conversion process leading the way. This process can convert any low-moisture carbon feedstock, including coal and waste coal. The process also allows for easy capture of excess carbon gas and significantly reduces greenhouse gas emissions inherent in landfill operations.

Animal Waste

The Virginia Waste Solutions Forum, a grassroots, multidisciplinary group of researchers, farmers, economic development interests, state government, and others, focuses on innovative solutions and strategies to improve water quality by dealing with excess nutrients generated by animal agriculture in the Shenandoah Valley. One promising option under consideration and study by the forum is to use agricultural waste as a feedstock for energy production.

Biomass

The Virginia Center for Coal and Energy Research estimates there is a potential for 760 megawatts of new electrical generation in Virginia from biomass. Forest residues could potentially support about 530 megawatts of electric generation. Other biomass resources include urban wood residues (180 megawatts), unused mill residues (14.5 megawatts), crop residues (32.8 megawatts), and animal manure (12.3 megawatts).

Several energy plants use wood or wood wastes as fuel sources. The largest is in Pittsylvania County and is owned and operated by Dominion. Consisting of three boilers and one 80-megawatt turbine unit, it consumes about 750,000 tons of wood per year.

See Chapter 4 for a more in-depth discussion of biomass.

Wind

Virginia has significant land-based and offshore wind energy resources. The potential installed capacity of land-based wind power in available Class 4 and higher resource areas within 20 miles of existing transmission lines is a little over 600 megawatts. An additional 750 megawatts could be installed if and when Class 3 land-based wind resources become economical. Class 3+ sites more than 20 miles from existing transmission lines could account for an additional generation capacity of nearly 600 megawatts. This yields a total potential land-based wind generation capacity of 1,950 megawatts.[24]

Offshore wind power located beyond the horizon of Virginia's Atlantic Coast, in Class 6 winds and in water depths less than 20 meters, could be economically feasible today. The potential installed capacity is about 740 megawatts. Harnessing Class 5 and 6 offshore winds in water depths less than 40 meters within 50 miles of the coast requires either monopile or truss-work foundations, both of which have been installed in European waters. The potential generation in this area is 28,100 megawatts.[25]

Wind power data produced by AWS TrueWind Solutions characterized Virginia's wind energy resource and produced an area breakdown based on wind class and type of land ownership. In March 2006, Virginia asked the National Renewable Energy Laboratory (NREL) wind-mapping group for a GIS analysis of near-shore wind data as an extension of AWS's work. Table 2-7 shows the area estimates for the distribution of Virginia's wind resources among different types of lands and waters.

[24]Actual production may be less because of lands unsuitable for wind development and low capacity factors of wind systems.
[25]National Renewable Energy Laboratory, "A Study of Increased Use of Renewable Energy Resources in Virginia," Appendix A, pp. A-3-A-4, November 11, 2005.

Table 2-7 Virginia's Wind Energy Resource Areas *(km^2)**

Type of Area	Class 3	Class 4	Class 5	Class 6
Fish and Wildlife Service	80	7	0	0
National Park Service	119	67	35	29
USDA Forest Service	598	291	145	102
Department of Defense	33	0	0	0
Private	844	265	61	38
All other lands	12	4	2	2
All Land-Based	**1,686**	**634**	**243**	**171**
Inland waterways	50	46	0	0
Chesapeake Bay	923	3,018	181	0
Atlantic Ocean (to 3 n.mi.)	277	823	566	0
All State Waters	**1,250**	**3,887**	**747**	**0**
3 to 6 n.mi. offshore			824	0
6 to 20 n.mi. offshore			3,205	2,111
20 to 50 n.mi. offshore			8	10,668
All Federal Waters			**4,037**	**12,779**
TOTAL ALL AREAS	**2,936**	**4,521**	**5,027**	**12,950**

*Estimates for land-based and state waters from AWS Truewind. Area estimates for federal waters based on NREL analysis, out to 50 nautical miles, Class 5 and 6 areas only.

Solar-powered electricity is attractive as it is emissions free and there is an ample solar resource.

Adjustments to this table must be made to exclude sensitive areas unsuitable for development when calculating the actual wind potential. This would exclude turbines out to 6 nautical miles and in most of the waters of Chesapeake Bay, and include only 67 percent from 6 to 20 nautical miles offshore and 33 percent from 20 to 50 nautical miles offshore because of potential ocean use conflicts.

Achievable capacity will depend on advancements in technology, reductions in cost, capacity of suppliers and installers to meet market demands, and ability to move sites through legal approval and community acceptance.

Solar

There are many developed technologies to take advantage of solar energy, among them passive solar heating, daylighting, solar hot water, and photovoltaic (PV) systems.

Many low-tech solar options are available to Virginia now. Passive solar is the most basic form of solar energy. Buildings that use passive solar and other green design concepts are less expensive to operate and maintain, provide a healthier environment for occupants, and increase worker productivity. Passive solar for light and heat generally does not increase the cost of new construction.

Market barriers for passive solar buildings include construction techniques that are different from standard practices and building appearances that do not always conform to what the community or customer expects.

A typical residential solar water heating system for a family of four delivers 4 kilowatts of electrical equivalent thermal power under full-sun conditions. For every solar hot water heating system installed, an average of 0.5 kilowatts of peak demand is offset from a utility's load.[26]

Solar-powered electricity is attractive as it is emissions free and there is an ample solar resource. Solar PV cells are made of semiconducting materials similar to those used in computer chips. When these

[26]Solar Thermal Collector Energy Production Produced by the Solar Rating and Certification Corporation, www.solar-rating.org.

materials absorb sunlight, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. PV cells can be either crystalline silicon (single crystal or polycrystalline) or thin film using materials such as amorphous silicon, cadmium telluride, or copper indium gallium diselenide. Most recently, nanotechnology has entered the field with materials that can be sprayed or printed onto a variety of substrates. These have the potential to reduce costs when compared with conventional crystalline and thin film technologies. However, PV costs are still high today and do not compete well financially with conventional sources and other renewables.

While direct costs of solar PV power are high, there may be indirect benefits to utilities when solar PV power is deployed in their service territories. In Texas, the City of Austin's municipal electric utility reports that the value of distributed PV power is in the range of 11 to 12 cents per kilowatt hour. The cost per kilowatt ranged from $1,983 to $2,938.[27] While conditions differ in Virginia and the state's electric utilities would not receive the same level of benefit, this study shows the potential value of solar PV production to the state's electric utilities.

Local governments have the authority to exempt solar energy property for property tax purposes. Only a minority of Virginia localities have implemented this option.

The Virginia Center for Coal and Energy Research reports that Virginia has the technical potential for 11,000 megawatts if using horizontal, roof-integrated panels and 13,000 megawatts if using tilted arrays on existing rooftops. Forty percent would be installed on commercial buildings and 60 percent on residences.

These systems, integrated into the electric grid, could support local distribution systems during peak demand, provide reactive power control, support disaster recovery, provide a hedge against fuel-cost uncertainties, and provide other benefits. Solar electric is especially valuable in off-setting peak demand in summer, the best time for solar energy generation.

Solar PV manufacturing offers great potential for economic development in the coming years. The *PV Roadmap*, an industry-led effort to assess the best mix of research and market development, predicts that with a reasonable set of incentives, the solar PV market in the United States could grow more than 30 percent a year over the next twenty years, increasing from 340 megawatts of installed capacity to 9,600 megawatts in 2015. *PV Roadmap* also predicts that the average installed cost in 2015 could be $3.68 per watt ($2.91 for manufacturing and $0.77 for construction and installation). This would require a $27 billion investment in manufacturing and $7 billion investment in construction and installation. Direct employment could increase from 20,000 jobs today to 62,000 jobs by 2015. The report ranked Virginia fifteenth in the nation in potential investment and job creation (640 jobs and $550 million investment) if the predicted trend is reached.

Virginia has been host to two PV manufacturers, one of which ceased operations in 2002. Virginia offers the Solar Manufacturing Incentive Grant Program, which awards up to $4.5 million a year for the sale of Virginia-manufactured PV panels. However, this grant no longer has been able to attract new solar panel manufacturing. Over the past year, eight PV manufacturers have expressed interest in locating manufacturing plants in Virginia, but none have committed. One of the companies expanded in Germany, where it received a combined package of direct incentives, coupled with significant end-user incentives such as a generous feed-in tariff for solar-generated electricity. A second, Midwest company decided the Virginia grant alone was not worth disrupting its current workforce and instead expanded operations in its home state. A third company told Virginia economic development representatives that the grant incentive, originally developed to support a less-than-10-megawatt facility in the 1990s, is not sufficient to attract the current required investment by modern

[27] Thomas E. Hoff, Richard Perez, Gerry Braun, Michael Kuhn, and Benjamin Norris, "The Value of Distributed Photovoltaics to Austin Energy and the City of Austin," prepared by Clean Power Research, L.L.C., March 17, 2006.

PV manufacturers. The program could be updated to attract investments in a different market from when the program was originally introduced.

2.6.2 Long-term Technologies

Geothermal Energy

The term "geothermal energy" is popularly associated with bubbling hot springs and geysers, where volcanic activity produces temperatures above the boiling point of water near the earth's surface. Such high-temperature geothermal reservoirs do not exist in the eastern United States. There are two low-temperature reservoirs in Virginia.

Virginia's western low-temperature reservoir is associated with aquifers that circulate and heat groundwater, then return it to the surface to hot springs clustered around Highland and Bath Counties, with water temperatures typically ranging from 70 to 105°F. In the Warm Springs area, there is considerable lower-temperature water available. This resource is used for space heating at The Homestead resort complex.

Virginia also has an eastern low-grade geothermal reservoir around Chesapeake Bay, where groundwater temperatures of 75 to 80°F are found about 1,000 feet below the surface. The heat comes from granite bodies that contain relatively high concentrations of radioactive isotopes. These granite intrusions are overlain by a thick layer of Coastal Plain sediments, which act as an insulating blanket, allowing the heat to build up and create a relatively high geothermal gradient. This formation is a candidate for a longer-term geothermal conversion technology known as hot dry rock, which uses the hot temperatures of underground granite rock layers.

Tidal/In-Stream Water

Tidal changes in sea level can be used to generate electricity. Dams can be constructed across coastal bays or estuaries that have large differences between low and high tides. The changing water levels create pressure that can drive turbines to make electricity. However, any tidal power development would have to address serious environmental impacts from constructing impoundments across coastal bays or estuaries.

Offshore turbines function similarly to an underwater wind farm. They are much cheaper to build and do not have the environmental problems of tidal barriers. Water is denser than wind; therefore, fewer and smaller offshore turbines are needed to produce the same amount of electricity as wind turbines.

Wave-based generation systems are also being tested for future use. It is not known whether these would be applicable for Virginia waters.

Hydrogen

Developing hydrogen is a current federal government priority. Drawbacks are high production costs and lack of storage and transport infrastructure. To succeed in the commercial marketplace, hydrogen transportation costs must be competitive with conventional fuels and technologies. Automotive fuel cells are advancing, but key technical challenges remain. Goals include lowering the cost of automotive fuel cells to be competitive with the internal combustion engine, increasing durability to 5,000 hours to achieve parity with conventional automobiles, and creating the on-vehicle safe storage of enough hydrogen to allow a 300-mile cruising range.

The Virginia Hydrogen Economy Roundtable Forum published in 2006 a state hydrogen plan and vision titled *Building a Hydrogen Economy in Virginia, Suggested Strategies*. The forum was established in 2002 and includes representatives from more than thirty energy- and transportation-related industries, federal and state government agencies, Virginia academic institutions, and nongovernmental organizations. Five priorities were recommended.

- Educate Virginia's future workforce, focusing on K-12 education.

Marketing Virginia's core strengths – research and development, nuclear, proximity to markets, resources, and conservation and efficiency opportunities – could have a significant impact on economic development in the energy sector.

- Leverage the research and development potential of Virginia's academic institutions.
- Invest in hydrogen demonstration projects with high visibility.
- Foster partnership building.
- Coordinate policies and incentives to drive the building of a hydrogen economy in Virginia.

The plan includes a range of options for each of the first four action items, several possible approaches for policy development, and an incentives strategy. The 2007 General Assembly approved funding for a pilot K-12 education program.

Methane Hydrates

A methane hydrate is a form of natural gas where the molecules of methane are trapped inside a lattice of ice. Hydrate deposits may be several hundred meters thick. Methane hydrates usually form either in permafrost regions on land or beneath the ocean floor. Methane hydrate occurs around most continental margins. Virginia's coastal regions may offer methane hydrate resources.

If just 1 percent of the nation's hydrate resources were commercially developed, it would more than double the nation's proven gas reserves. Although commercial extraction is at least ten years off, methane hydrate merits research.

2.7 Opportunities and Challenges

Transmission Constraints - Electricity

Virginia, especially northern Virginia and the Delmarva Peninsula, is faced with electric transmission constraints. The electric transmission network must be expanded to provide efficient and reliable delivery to areas of high growth.

Electrical demand in northern Virginia has grown by approximately 40 percent over the last decade. PJM recently cited Dominion as having the fastest growing demand for electricity at peak times among any of the PJM regions across thirteen states. PJM compared the increase in demand on the Dominion system to adding approximately a million new houses over the next five years. PJM's analysis shows that without increases in transmission infrastructure to keep the northern Virginia portion of the system stable, northern Virginia electric consumers face an increasing risk of rolling blackouts as early as summer 2011.

Transmission Constraints - Natural Gas

Tidewater is sensitive to natural gas constraints. Virginia Natural Gas is developing a Hampton Roads Crossing project, which will add a third pipeline across the James River and alleviate some of the Tidewater constraint by providing additional capacity to transport natural gas through the region. Other regions in Virginia may become sensitive to natural gas constraints as the state's economy grows.

Priority

Marketing Virginia's core strengths–research and development, nuclear, proximity to markets, resources, and conservation and efficiency opportunities–could have a significant impact on economic development in the energy sector. This could be accomplished through improved coordination of Virginia's research institutions and technology sector (see Chapter 6) and through coordinated efforts of Virginia's economic development offices and interests (Virginia Economic Development Partnership, local and regional economic development offices, industrial development authorities, and private developers).

Potential

By matching its strengths and resources, Virginia has the opportunity to improve its ratio between imports and production. Efficiency and conservation opportunities (Chapter 3) reduce the need for imports. New production can supplement and replace older, less efficient generation sources. Each 1 percent shift from producing more energy or using less can have a significant impact on Virginia's economy (see Table 2-8). For example, data show that a 1 percent shift in petroleum use to

Virginia sources would retain over $100 million in Virginia's economy. A similar shift of electrical generation would keep $20 million in the state's economy and in natural gas production would keep over $12 million in the state's economy.

Table 2-8 Impact of 1 Percent Change in Virginia's Energy Imports/Exports

CHANGE IN NET IMPORTS					
Fuel	2007 Net Imports (Billion BTUs)	1% of Net Imports (Billion BTUs)	Equivalent Amount	Units	Market Value ($Million)
Natural Gas	190,399	1,904	1,851,420	MCF	$12.8
Petroleum	1,006,590	10,066	1,728,051	BBS	$114.1
Electricity	109,472	1,095	320,750	MWh	$20.1
Uranium (U235)	300,850	3,009	14,329	lb	$0.7
CHANGE IN NET EXPORTS					
Fuel	2007 Net Exports (Billion BTUs)	1% of Net Exports (Billion BTUs)	Equivalent Amount	Units	Market Value ($Million)
Coal	364,609	3,646	136,227	Tons	$6.8
THERMAL CONVERSION FACTORS					
1 cubic foot of Natural Gas = 1,028.4 BTUs					
1 barrel of Petroleum = 5.825 Million BTUs					
1 kWh Electricity = 3,413 BTUs					
1 pound U235 = 210 Million BTUs					
1 pound of coal = 12,867.4 BTUs					

These actions will result in a modification of the energy supply and demand curves (see Figure 2-23). These supply and demand wedges will reduce the gap between supply and demand and reduce the drain on Virginia's economy from energy imports.

Figure 2-23 Virginia Total Energy Produced and Consumed, 1990-2016